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MOVEMENTS OF LYNX RELATIVE TO LANDSCAPE FEATURES

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Movements of lynx relative to landscape features

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INTRODUCTION

The Canada lynx (*Lynx canadensis*) was listed as "Threatened" under the Endangered Species Act in 2000, which has important implications for managing northern forests. The future of this species requires both healthy and connected populations, which correspond to successful lynx management at local and landscape scales, respectively. To best direct such multi-scale management, The Rocky Mountain Research Station, in cooperation with the Bureau of Land Management, Clearwater National Forest, Idaho Department of Transportation, and Region 1 of the USDA Forest Service began a multi-scale study of lynx movements in 2002.

We focus on understanding movement patterns of lynx at local and landscape scales with respect to habitat connectivity, corridor use, and responses to movement "barriers." Movements within home ranges and across the larger landscape reveal habitat choices at these differing scales. Specific concern about impacts of transportation corridors on lynx recently arose in the Biological Assessment and Biological Opinion for Lolo Pass, but there are few empirical data available to infer these impacts on lynx movement and ecology. We attempt to gain further insight into to this question as well, but we also recognize that collecting the necessary data is highly dependent on both the technology available and the frequency of interaction between study animals and transportation corridors.

Program Goal

To understand lynx movements relative to landscape and habitat features.

Specific Objectives

1) *Determine how lynx movements correlate to changes in landscape and habitat pattern, with consideration to different age classes (juvenal, subadult, adult);*

2) *Describe lynx dispersal in terms of extent, timing, and crossings of natural and anthropogenic barriers*

Project History

During January – March 2001, we completed 1,514 km of snow-track surveys in the Lolo Pass area and found no lynx. On 17 July 2001, RMRS met with Dan Davis (Clearwater NF) and Wayne Melquist (Idaho Fish and Game) and agreed that different study sites were needed to achieve our objectives. Consequently, we surveyed and trapped in areas that supported suitable lynx populations and were close or contiguous to Lolo Pass: the Garnet Range and Purcell Mountains, Montana.

In the Garnet Range we have captured 7 lynx since 2002. After 6 mortalities, we are currently monitoring 1 animal (Female 104). In the Purcell Mountains we have captured 15 lynx during two winters (2003, 2004) and are currently monitoring all 15 (10 males, 5 females).

Upon designing this study, our intent was to deploy collars that used GPS technology to collect precise location data and used the *Service* Argos satellite system to transmit these data for remote download. One telemetry manufacturer promised to provide such a collar during the winter of 2003, but the product that arrived was not adequately tested and ultimately did not work. Since then, we have worked closely with other telemetry manufacturers in the

development and testing of available products, and unanticipated setbacks continue to delay the production of a GPS/Argos satellite collar suitable for lynx research (~200 grams).

While a significant impediment to our study, this complication has not prevented us from collecting movement data to best answer our objectives. We still require precise GPS location data to study lynx movements (Objective 1), but have begun using newly available store-on-board GPS collars as a surrogate to collect such data until remotely transmitting collars are achieved. This technology is not suitable, however, for studying dispersal (Objective 2), given the high probability of losing animals (and their store-on-board data) during long range exploratory or dispersal movements. Thus, we are using straight Argos satellite technology on lightweight collars to monitor our youngest age classes of lynx (those most likely to disperse).

METHODS

Study areas (Nodes)

Our research incorporates multiple study areas, or "nodes," representing lynx populations widely distributed across northwestern Montana. This allows similar data to be collected across a much greater region than is typical. Our goal when identifying study nodes was to select areas well distributed across northwestern Montana that supported suitable lynx populations. We preferentially selected study nodes in major linkage zones as identified by the U. S. Forest Service and in areas that included major transportation corridors. Our research focus at Seeley Lake, Montana, is also shifting to include broad-scale movement patterns, which will directly compliment this study.

1) The Garnet Range

The Garnet Range lies roughly 25 km south of our Seeley Lake study area, and is the closest area to Lolo Pass with an adequate number of lynx to support a study (Figure 1). Movements between the Garnet Range and areas near Lolo Pass have been documented (Smith 1984), and the area is an island surrounded by transportation corridors, including Highways 200 and 141 and Interstate 90. Lynx making long distance movements to Seeley Lake or Lolo Pass must cross these highways.

2) The Purcell Mountains

The Purcell Mountains lie in the northwest corner of Montana (Figure 1), and local biologists have documented lynx presence in the recent past. The area includes primary Highway 2, and secondary highways 508 and 567. At this point, the majority of our efforts have been bounded to that part of Montana north of Highway 2 and west of Lake Koocanusa, though we are also interested in documenting lynx distribution in the neighboring Salish Mountains to the east.

3) *Potential Node*: The Cabinet Mountains

The Cabinet Mountains lie to the south of the Purcells, and include terrain that is contiguous with Lolo Pass (Figure 1). A female lynx once moved from this region, near Fishtrap Creek, to Radium Hot Springs, British Columbia (Brainerd 1985); this female crossed the Highway 2 transportation corridor to accomplish this movement. We have conducted preliminary carnivore surveys in these mountains, but with much less intensity than in the

Purcell and Garnet Nodes. Work will remain very limited in this area pending additional funding.

Snow-track surveys

We have developed a formal protocol for surveying landscapes for forest carnivores, with an emphasis on detecting lynx (Squires and Ruggiero, *in press*). We used snow-track surveys to document lynx presence within each study node; this is a necessary step towards efficiently collaring lynx to meet research objectives. We divided each study node into smaller survey units by overlaying a grid of 64 km^2 pixels in a GIS with each 64 km^2 pixel serving as a single survey unit. This process aided in distributing survey effort evenly across each node. The 64 km^2 pixel size was based on an average female home range for lynx at Seeley Lake (Squires and Laurion 2000). We traveled roads and trails by snowmobile and snowshoe to detect carnivores via tracks in the snow and standardized our search effort within pixels to a minimum of 10 km. We preferentially searched the best lynx habitat within each pixel based on our research experience in Seeley Lake.

In the Garnet Range, we surveyed all pixels except those dominated by private land or non-lynx habitat; we defined "non-lynx" habitat as low dry sites with little forest cover. In the Purcell Mountains we used local knowledge and an adaptive cluster sampling method to rapidly and efficiently locate lynx (Thompson 1992). We began our surveying in pixels where lynx had been previously documented by local biologists and then used the adaptive cluster method to prioritize pixels for future survey. As soon as we detected lynx tracks in a pixel, we surveyed all 8 surrounding pixels (where possible). If we detected lynx in one of the neighboring 8 pixels, we then surveyed those 8 pixels surrounding that pixel, and so on. This method quickly delineates clusters of pixels that contain lynx, and those surrounding pixels that may not.

We documented all tracks of lynx, bobcat (*Lynx rufus*), mountain lion (*Puma concolor*), wolf (*Canis lupus*), coyote (*Canis latrans*), wolverine (*Gulo gulo*), fisher (*Martes pennanti*), and marten (*Martes americana*) and used Trimble GeoExplorer 3 units to log field data. This included spatial data like survey routes and carnivore track locations, as well as associated attributes such as weather, snow conditions, habitat type, and track measurements. We provided further documentation of "rare" carnivores (lynx, bobcat, mountain lion, wolf, wolverine, and fisher) by describing track condition, species ID certainty, activity, snow conditions, and track and gait measurements. Measurements included stride, straddle, track length and width, track depth in snow, and snow depth in track. We also took photographs to complement gait and track measurements of most rare carnivores. We recorded snowshoe hare (*Lepus americanus*) tracks periodically to facilitate comparisons of prey densities across nodes.

Capture and handling

We have radio-collared over 100 lynx in Montana since initiating a study in Seeley Lake in 1998. Based on this experience, we trapped lynx for this study using specially designed box traps (Kolbe et al. 2003) in high activity areas as deemed by snow tracks, habitat and topography. Trap sets were baited with deer carrion, beaver castor (a scent lure), and pie plates and wings (visual lures). Animals captured in box traps have a very low risk of injury, and non-target animals or recaptures can be easily removed without sedation. Trapping was conducted mid-winter and traps were checked either daily or every two days.

We also have several years of experience using hounds to tree collared lynx for collar replacement. Optimal conditions for this are those of spring or fall when ground moisture is

high. Telemetry allowed us to bring a group of hounds (generally 2-4 Treeing Walker hounds) close to the animal before turning them loose; close slips generally provided shorter chase times and less stress on the lynx. Once the lynx was in a tree, we used spur/lanyard climbing in combination with safety ropes to dart and safely lower the animal for processing.

We chemically immobilized lynx using ketamine (10 mg/kg *Ketaset*®; concentration 100 mg/mL) and xylazine (1 mg/kg; concentration 100 mg/mL). Capture drugs were administered from a syringe pole, and this dose produced predictable immobilization periods (30-40 minutes) and stable vital signs. We fitted adult lynx with VHF radio transmitters (170g) or store-on-board GPS collars (both temporary substitutes until a remotely transmitting GPS collar is available), weighed and measured them, and extracted blood for future DNA analysis. We fitted lynx kittens with lightweight VHF (100g) or Argos *Cricket* PTT (130g) collars using degradable padding to ensure long-term fit.

GPS tracking of movements

Integrating GPS technology with lynx telemetry is a major step in obtaining relocation data to study lynx movements. However, we have encountered many setbacks in our effort to obtain such technology as manufacturers are only now beginning to work with collars in a suitable weight range for lynx (~ 200 grams). Because a remotely transmitting GPS collar is still not developed for lynx, we have begun using newly available store-on-board collars as a temporary surrogate. Rigorous testing ensured that collars could perform well under the thick canopy of typical lynx habitat. Thus the main complication with these collars is our need to recapture the animal to retrieve data.

Our goal is a large dataset of 24-hour lynx tracks for multiple seasons and animals. During the winter of 2004 we deployed 2 GPS collars on lynx and obtained a pilot data set. These collars were programmed to collect a fix every hour for the duration of the battery life. We recaptured animals and downloaded data from these collars to better inform our collar programming for the summer 2004 season. For this summer, collars were programmed to collect a fix every 30 minutes for a systematic sample of 24-hour periods; these collars will turn on every other day, for 24 hours at a time, and collect fixes every 30 minutes while they are on. Assuming successful retrieval of all deployed collars, we expect a dataset of over 350 24-hour tracks from the summer of 2004.

Dispersal

Once remote data downloading is made possible with GPS data, it will be an ideal technology for studying lynx dispersal. Until that time, we are forced to use the conventional VHF (radio) beacons to keep track of the lynx and its precious store-on-board data. Previous studies in Seeley Lake indicate that VHF is not always an adequate tool for monitoring lynx during long distance dispersal movements, and several animals have been lost.

This concern forced us to a different technology that does allow remote downloading, *Service* Argos. Originally developed for marine applications, an Argos transmitter uses Doppler shift technology and NOAA satellites to obtain fixes available for remote download over the Internet. Unfortunately, these transmitters do not perform as well under the forest canopy conditions of lynx habitat, and provide only a crude estimate of the animal's true location. We have used Argos transmitters on lynx collars in previous studies. While they have not provided accurate fine-scale location data for monitoring local lynx movement, they have allowed us to

remotely track long distance movements by animals that would likely have been lost using conventional VHF telemetry. Thus Argos is a valuable tool in studying lynx dispersal.

Research in Seeley Lake has suggested that younger age classes of lynx are the most likely to disperse. For this reason, we have targeted first-winter kittens (9 months old) for our Argos-based study of lynx dispersal. We have worked closely with telemetry manufacturers to develop a 135 gram collar light enough for deployment on kittens, with an Argos transmitter for remote monitoring. The first batch of these collars was deployed during the winter of 2004, and we expect dispersal and exploratory movements to commence during the summer of 2004.

RESULTS

Snow-track surveys

1) Garnet Range Node

We have surveyed in the Garnet Range for 2 winters (2002, 2003). In 2002, we intensively surveyed 242 km of roads and trails for all carnivores and surveyed for only lynx on an additional 220 km of roads. During surveys for all carnivores, we documented lynx tracks (n = 37) in 4 of 12 pixels surveyed (Figure 2), roughly between Elevation Mountain and Union Peak. Coyote tracks were very common (n = 160), and we also detected marten (n = 1) and mountain lion (n = 10) during these surveys (Figures 3, 4; Table 1). We detected an additional 115 lynx tracks during lynx-only surveys.

In 2003, we expanded our effort eastward across a larger grid of survey pixels and surveyed 438 km of roads and trails for all carnivores. We detected lynx (n = 37) in similar areas to those of 2002, and in 4 of 16 pixels surveyed (Figure 5). Again coyotes were the most common (n = 249), and we also detected bobcat (n = 6), marten (n = 1), mountain lion (n = 14), and wolverine (n = 1) (Figures 6, 7; Table 1). We documented additional tracks for each of these species except marten during time spent in the field trapping (Table 1). A comparison of tracks across both survey years indicates that lynx are fairly localized in the high elevations of the Garnet Range near Elevation Mountain and the Garnet Ghost Town (Figure 8).

2) Purcell Mountains Node

During two winters (2003, 2004) of surveying in the Purcell Mountains, we have intensively surveyed 828 km of roads and trails. We found lynx (n = 116 tracks) in 20 of 44 pixels surveyed (Figure 9). Lynx were generally located in the northern portion of the study area, with detections in upper elevations of Big Creek and its tributaries, Boulder Creek, Cool Creek, Pete Creek, Sullivan Creek, and the West Fork of the Yaak River. Marten (n = 341) were most common, and we also detected bobcat (n = 33), mountain lion (n = 15), wolf (n = 10), and wolverine (n = 1) tracks during surveys (Figures 10, 11; Table 2). After documenting several hundred coyote tracks (Squires et al. 2003), we stopped recording them to increase survey efficiency. We opportunistically documented additional tracks for rare species while trapping or doing reconnaissance in the field, and we also recorded all lynx tracks along our trapping routes after surveying was completed (Table 2).

3) Cabinet Mountains Survey Area

Although funding is currently unavailable for this node, we surveyed 183 km of roads in the Cabinet Mountains during the winter of 2002. We detected many coyote tracks (n = 102) and a single mustelid (fisher or marten), but we did not detect any lynx (Figure 12; Table 3).

Interpreting Survey Results

These data are the result of survey efforts primarily focused on lynx. We generally biased our survey routes towards lynx habitat in 2 ways: 1) We concentrated our survey effort in pixels most likely to have lynx, and 2) Within each pixel, we surveyed in habitats deemed suitable for lynx. Because of these biases, these data should not be considered indicative of population sizes for carnivores in the Garnet Range, Purcell Mountains or Cabinet Mountains. Instead, they are a sample of the distributions of carnivores (primarily lynx) across the region.

Capture and Monitoring

1) Garnet Range Node

We have trapped for 2 winters (2002, 2003) in the Garnet Range (Table 4). In 2002 we captured 5 lynx, including 1 adult male (M82), 2 adult females (F90, F96), and 2 kittens (M94, F95), both offspring of F96. By June 2002, we lost 3 of these animals to mortality (M82, M94, and F96) and one slipped a collar (F95).

In the winter of 2003, we recaptured F95, and captured 2 new adult lynx (F104 and M101); these same animals were recaptured a total of 8 times throughout the trapping season. We trapped for 264 trap-nights, with 88 trap-nights per new individual and 24 trap-nights per capture. However, these are not traditional trap-night data because we often pre-baited areas and waited for lynx activity before setting traps. F95 died in April 2003 and F90 died of starvation during the winter of 2004.

Our target animals for the 2004 winter trapping season were 3 kittens born to F90 during the spring of 2003. We were unable to locate sign of these kittens after F90's mortality during the winter, and thus did not intensively trap the Garnet Range in 2004. We attempted to recapture M101 with hounds in June 2004, for deployment of a GPS collar, but these attempts were unsuccesful. Later in July 2004, M101 died from mountain lion predation. This leaves us currently with a single marked lynx in the Garnet Range, F104.

2) Purcell Mountains Node

We trapped in the Purcell Mountains during the winters of 2003 and 2004 (Table 4). In 2003, we captured and instrumented 6 adult male lynx (M200 – M205) during 533 trap-nights for an average of 89 trap-nights per new individual. We had an additional 7 recaptures of these animals, for an overall average of 41 trap-nights per capture. In 2004, we captured an additional 9 animals (Females F206, F208, F211, F212, F214 and Males M207, M209, M210, M213) and had 84 recaptures of 13 lynx during 1479 trap nights. We averaged 164 trap nights per new individual and 16 trap nights per capture. Like in the Garnets, our trap-night data are affected by pre-baiting and selectively trapping. We fitted 2 lynx (M200 and M202) with store-on-board GPS collars, for collection of a pilot GPS data set. All other adult lynx were fitted and released with conventional VHF transmitters for future replacement with satellite collars, and 2 kittens (M209 and M213) were fitted with padded ARGOS-based satellite telemetry for monitoring of dispersal.

In June, 2004, we obtained a new batch of store-on-board GPS collars that were custom designed to be ergonomic and lightweight for lynx. We used hounds to recapture 6 lynx (M201, M202, M203, M205, M207 and M210) and replaced 5 VHF and one of the original GPS collars with these new ones; we didn't wish to disturb denning females and thus recaptured only males during this period. We have observed no mortalities in the Purcell Mountains as of yet, and all 15 animals are currently being monitored.

GPS tracking of movements

We deployed 2 GPS collars on adult male lynx in the Purcell Mountains in early-February, 2004. Collars were programmed to collect hourly locations throughout the winter. We then recaptured these animals on 23 March, 2004, downloaded GPS collar data, replaced collar batteries, and re-programmed collars for a summer season of data collection. These 2 months of winter data are our first look at lynx movement with the aid of GPS (Figure 13). Fix success was 66%, with 1507 locations collected from 2286 attempts. Of these locations, 60% (n = 902) were 2D locations and 40% (n = 605) were 3D locations. We recaptured these animals several times ($N_{M200} = 21$, $N_{M202} = 23$) throughout the winter, and observed a decline in fix success while being held in a box trap. Because of this effect, we expect improved fix success rates for future data collected without concurrent trapping.

Recapturing these animals during the pilot data collection period also affects our ability to interpret their movements during these 2 months. However, we did gain valuable information about collar performance under forest canopy and the resolution of movement that hourly locations depict. In some cases, the lynx moved over 2 km between hourly locations, and we see only a straight line connecting those 2 points (Figure 14). For this reason, we reprogrammed the collars to collect locations every half-hour for the summer and all future data collection.

As mentioned above, we replaced one of these original GPS collars, and deployed an additional 5 custom-designed lynx collars in June, 2004. These collars are programmed to collect locations every 30 minutes for a 24-hour period, every other day. We expect to collect a total data set of 350 24-hour movement paths for GPS collared lynx this summer (n = 7), and a similar dataset the following winter.

Dispersal

We deployed 2 Argos-based satellite collars on lynx kittens in the Purcell Mountains in 2004. This is complimented by an additional 8 Argos collars deployed on kittens in our Seeley Lake study area to the southeast. Weekly remote data downloads are allowing us to monitor these kittens as they enter their first independent summer, though some collar failures have already occurred. Previous studies in Seeley Lake have suggested that kittens are most likely to disperse during these summer months; all kittens have remained in the vicinity of their natal home ranges to date.

ADDITIONAL RESULTS

Denning

Though not a primary objective of this study, we intensively monitor all collared females during the denning season to learn more about the fecundity and den site selection of these animals at new study sites. Successful females generally localize at a den site in May, and

repetitive telemetry during this time allowed us to detect such localizations. Several weeks after a female localized, we approached the site and searched for den sites and kittens. We collected DNA samples from kittens in the form of hairs and blood (ear prick), and measured vegetation data at den sites later in the summer to avoid disturbing the female at the time of denning.

1) Garnet Range

In May 2003, F90 became the first marked lynx to reproduce in the Garnets (Table 5). We located her natal and maternal dens and collected DNA from 3 kittens. Both den sites were within boulder fields, in needle and stick lined spaces under large boulders. Though we have been locating dens at our Seeley Lake Study area since 1999, these dens in the Garnet Range were the first recorded in rock.

In May 2004, F104 denned in the Garnet Range, producing a litter of 6 kittens (Figure 15). This is the largest litter recorded in Montana since research began in Seeley Lake in 1998. After 6 mortalities since 2002, F104 is currently our only marked lynx in the Garnet Range. We will target her for GPS technology and her kittens for lightweight Argos-based satellite telemetry during the 2005 winter to study local and broad-scale movements in the Garnets.

2) Purcell Mountains

In May 2004, we located den sites and kittens for all 5 collared female lynx in the Purcell Mountains (Table 5, Figure 16). Litter sizes varied at 1, 2, 4, 4, and 5 for females F211, F214, F208, F212, and F206, respectively, for a total of 16 known kittens. All dens were located in areas of heavy downfall, specifically under a single or network of downed logs. During winter 2005, we will also target these females and their kittens for GPS and Argos-based satellite technology.

Lynx and Elevation

We have collected a modest data set of VHF telemetry locations (n = 96) for 7 lynx in the Garnet Range, but available vegetation GIS layers seemed inadequate for a formal analysis habitat selection. Instead, we treated elevation as a surrogate for vegetation and used radio-telemetry location data to conduct a use-availability test for non-random use of elevation by lynx. Before pooling locations of all marked lynx, we used a one-way analysis of variance to test for differences in elevation use across individuals. We defined the habitat available to lynx as the sum of pixels surveyed for lynx in 2003; this excluded pixels that were deemed non-lynx habitat during surveys. We used our sample of telemetry locations to estimate lynx elevation use, and drew an equal, random sample of locations within this available area to estimate elevation availability. We conducted an independent samples T – test between elevation use and availability.

The one-way analysis of variance test for differences in elevation use between individual lynx returned insignificant results ($P = 0.334$); thus, we pooled locations of all marked lynx. Lynx used higher elevation habitats significantly ($T = 2.82$, $N = 96$, $P = 0.005$) more often than random expectation. The mean elevation used by lynx was 1748 m (5735 ft), with a 95% confidence interval of (1722 m, 1774 m) and range from 1443 m (4734 ft) to 2038 m (6686 ft). Lynx are typically associated with spruce-fir forests of these elevations (Aubry et al. 2000, McKelvey et al. 2000), and management changes to habitat at these elevations would be those most likely to affect the local population of lynx in the Garnet Range.

FUTURE DIRECTIONS

Seven GPS collars are currently deployed and collecting an unprecedented data set of lynx movements. These collars are additionally programmed to collect data during the upcoming winter, when we also hope to replace our VHF collared females with GPS technology. Two Argos collars are concurrently allowing us to monitor lynx kittens in the Purcell Range (supplemented by 8 deployed in Seeley Lake), as they approach the life-stage most likely to disperse. At this time, there is a single marked lynx surviving in the Garnet Range, but it is a female with a litter of 6 kittens. This female and her litter will be valuable assets in our continued studies of lynx ecology in the Garnet Range. We are still awaiting the arrival of a transmitting GPS collar, but are comfortable with store-on-board collars as a necessary surrogate. Transmitting collars will remove the risk of storing data within the collars should animals disperse or become difficult to recapture. We continue to work with manufacturers on this goal, as well as updating our GIS layers and analysis techniques for future work with an unprecedented dataset of lynx movements.

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Table 1. Carnivore tracks documented during snow-track surveys and outside of surveys (during reconnaissance and trapping efforts) in the Garnet Range, winters 2002 and 2003. We did not survey the Garnet Range in 2004.

	2002			2003		
Species	Tracks documented during surveys for all carnivores	Tracks documented during lynx-only surveys	**Total**	Tracks documented during surveys	Tracks documented outside of surveys	**Total**
Bobcat	0	0[a]	**0**[a]	6	3	**9**
Coyote	160	0[a]	**160**[a]	249	111	**360**
Lynx	37	91[a,b]	**128**[a,b]	37	53[b]	**90**[b]
Marten	1	0[a]	**1**[a]	1	0	**1**
Mountain lion	10	0[a]	**10**[a]	14	1	**15**
Wolverine	0	0[a]	**0**[a]	1	0	**1**

[a] In 2002, we recorded additional lynx tracks outside of our survey efforts, but did not record other species outside of survey efforts.
[b] We documented many lynx tracks outside of surveys due to repeated visits in high-use areas while monitoring lynx traps.

Table 2. Carnivore tracks documented during snow-track surveys and outside of surveys (opportunistic records during trapping or reconnaissance) in the Purcell Mountains, winters, 2003 and 2004.

	2003		2004		
Species[a]	Tracks documented during surveys	Tracks documented outside of surveys	Tracks documented during surveys	Tracks documented outside of surveys	Total
Bobcat	27	7	6	0	40
Lynx	96	323[b]	20	882[b]	116[b]
Marten	304	0	37	0	341
Mountain lion	15	9	0	2	26
Wolf	8	4	2	5	19
Wolverine	1	3	0	0	4

[a] After documenting several hundred coyote tracks (Squires et al. 2003), we stopped recording them to increase survey efficiency.

[b] We documented many additional lynx tracks outside of surveys due to repeated visits in high-use areas while monitoring lynx traps and did not include these in the survey total.

Table 3. Carnivore tracks documented during snow-track surveys in the Cabinet Mountains, winter 2002.

Species	Tracks documented during surveys
Coyote	102
Fisher/Marten[a]	1

[a] Identification of this fisher track was equivocal.

Table 4. Numbers of new lynx captured at the Garnet and Purcell study nodes during the past 3 winters, 2002-2004.

	2002				2003				2004				**Total**
Site	Males	Females	Kittens	Total	Males	Females	Kittens	Total	Males	Females	Kittens	Total	
Garnet	1	2	2	5	1	1	0	2	*Did not trap in 2004*				7
Purcell	*Did not trap in 2002*				6	0	0	6	2	5	2	9	15

Table 5. Litter sizes detected at female lynx den sites in the Garnet Range and Purcell Mountains, 28 May – 3 June 2003, and 24 May – 25 May 2004.

Study Node	Lynx	Spring Litter Sizes	
		2003	2004
Garnet Range	F90	3	Mortality[a]
	F104	0[b]	6
	Subtotal	*3*	*6*
Purcell Mountains	F206	na[c]	5
	F208	na[c]	4
	F211	na[c]	1
	F212	na[c]	4
	F214	na[c]	2
	Subtotal	*na*[c]	*16*
Total		*3*[c]	*22*

[a] F90 died during the winter of 2003-2004.
[b] Based on our monitoring, F104 did not localize at a den site during the 2003 denning season.
[c] We did not have any Purcell females collared during the 2003 denning season.

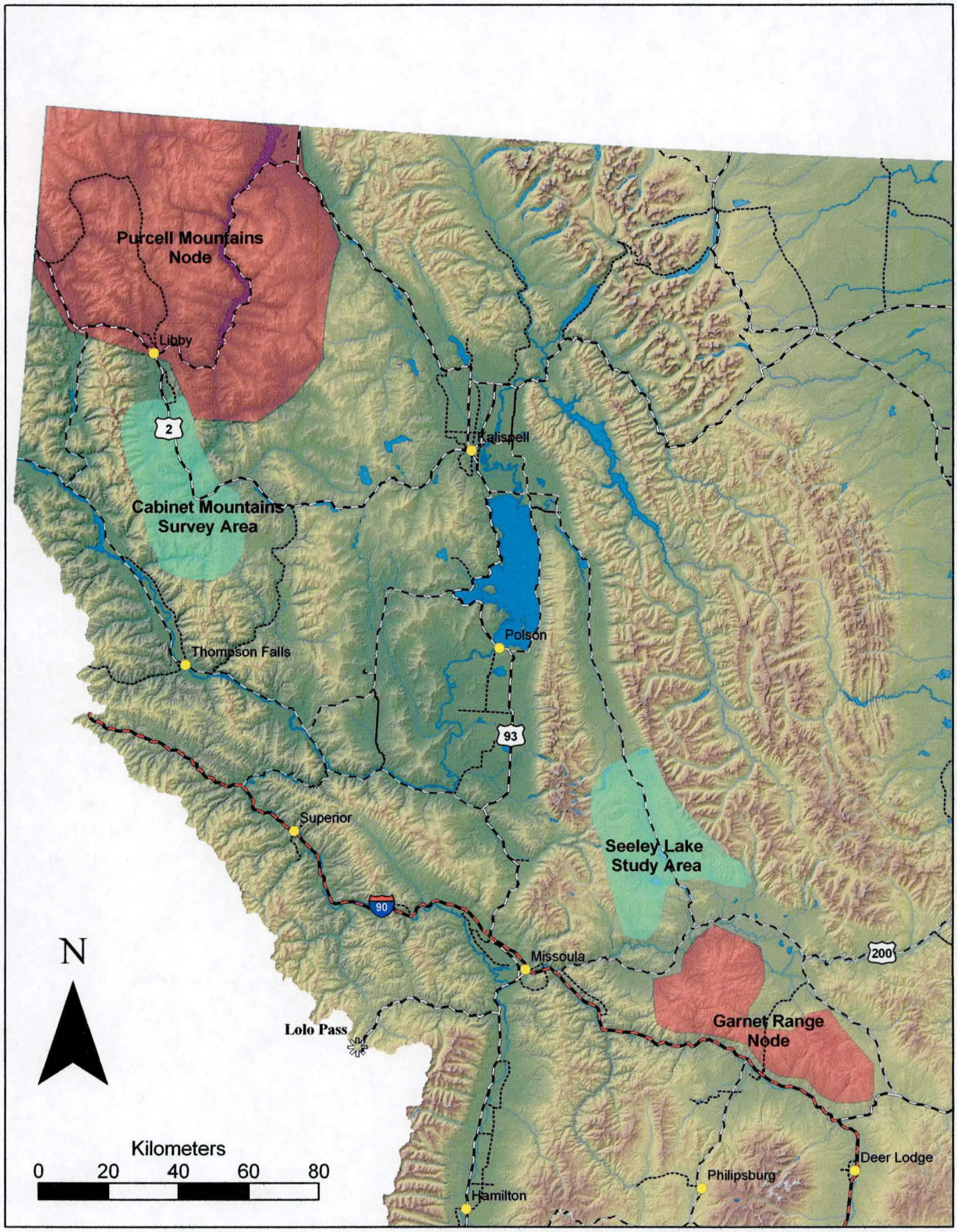

Figure 1. Lynx research study areas in western Montana, 2003. The Purcell Mountains and Garnet Range are nodes for the study of lynx movement through landscapes. Preliminary surveys have been conducted in the Cabinet Mountains, and related lynx research continues in Seeley Lake.

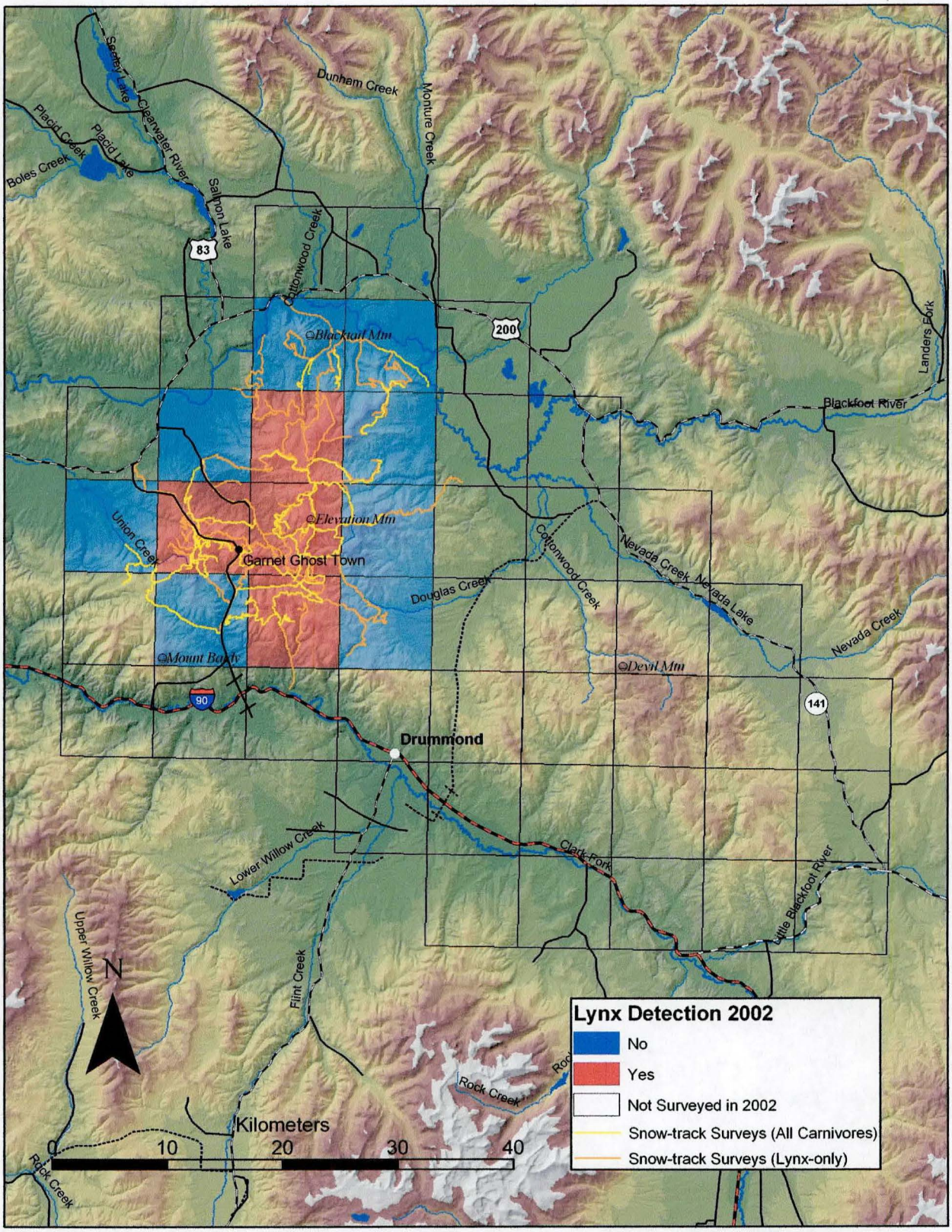

Figure 2. Survey pixels and snow-track survey routes in the Garnet Range, Montana, 2 February – 31 March 2002.

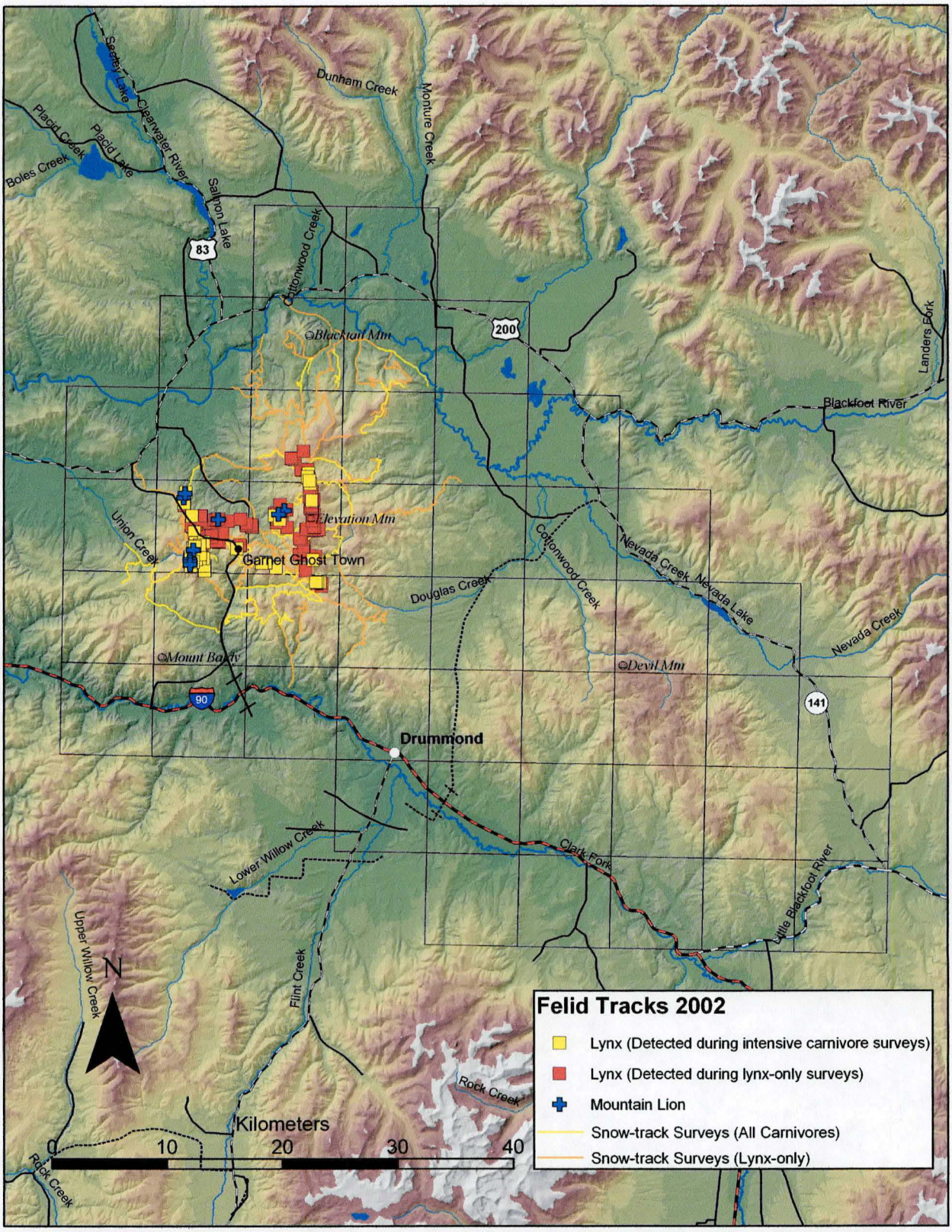

Figure 3. Felid tracks detected during snow-track surveys in the Garnet Range, Montana, 2 February – 31 March 2002.

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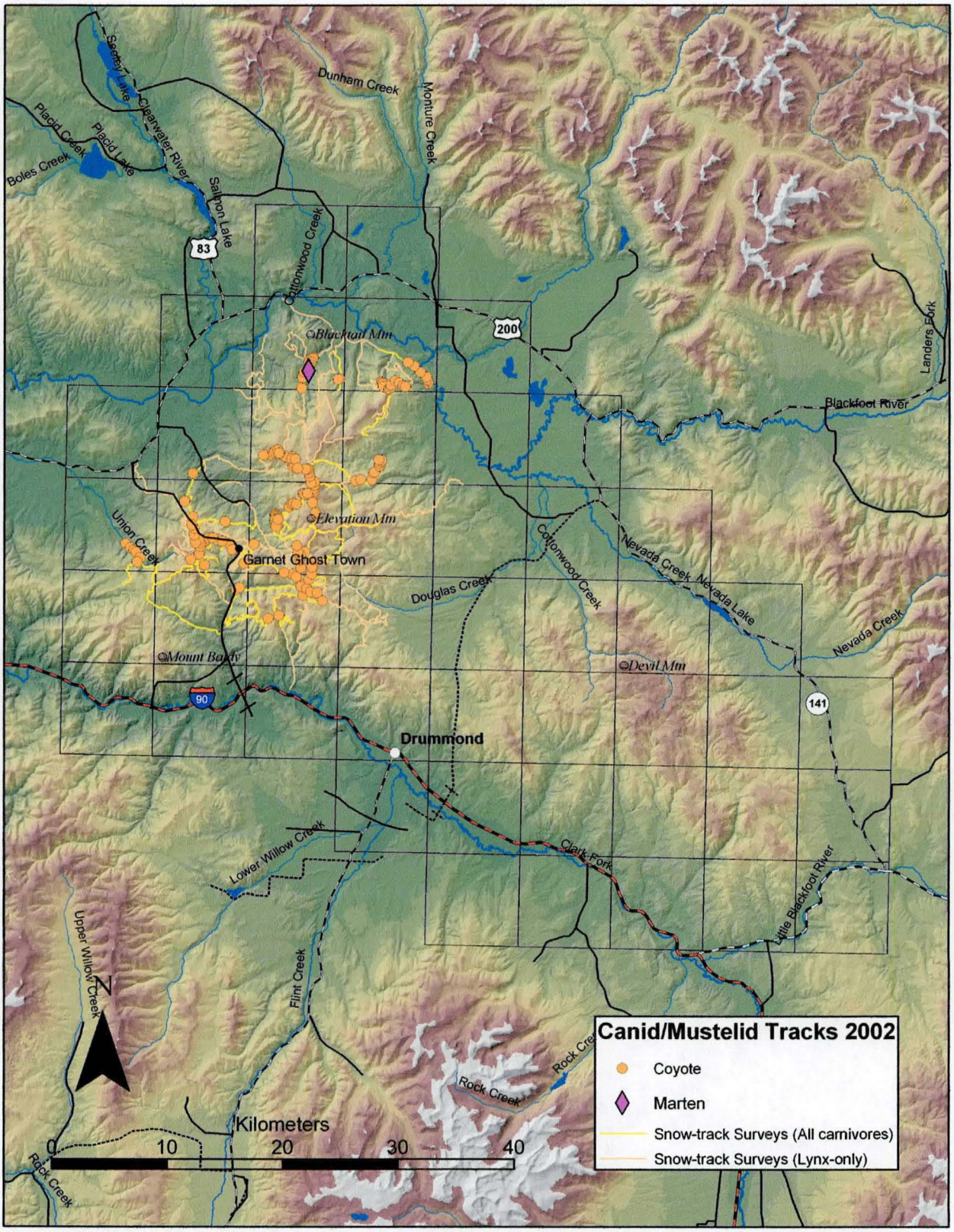

Figure 4. Canid and mustelid tracks detected during snow-track surveys in the Garnet Range, Montana, 2 February – 31 March 2002.

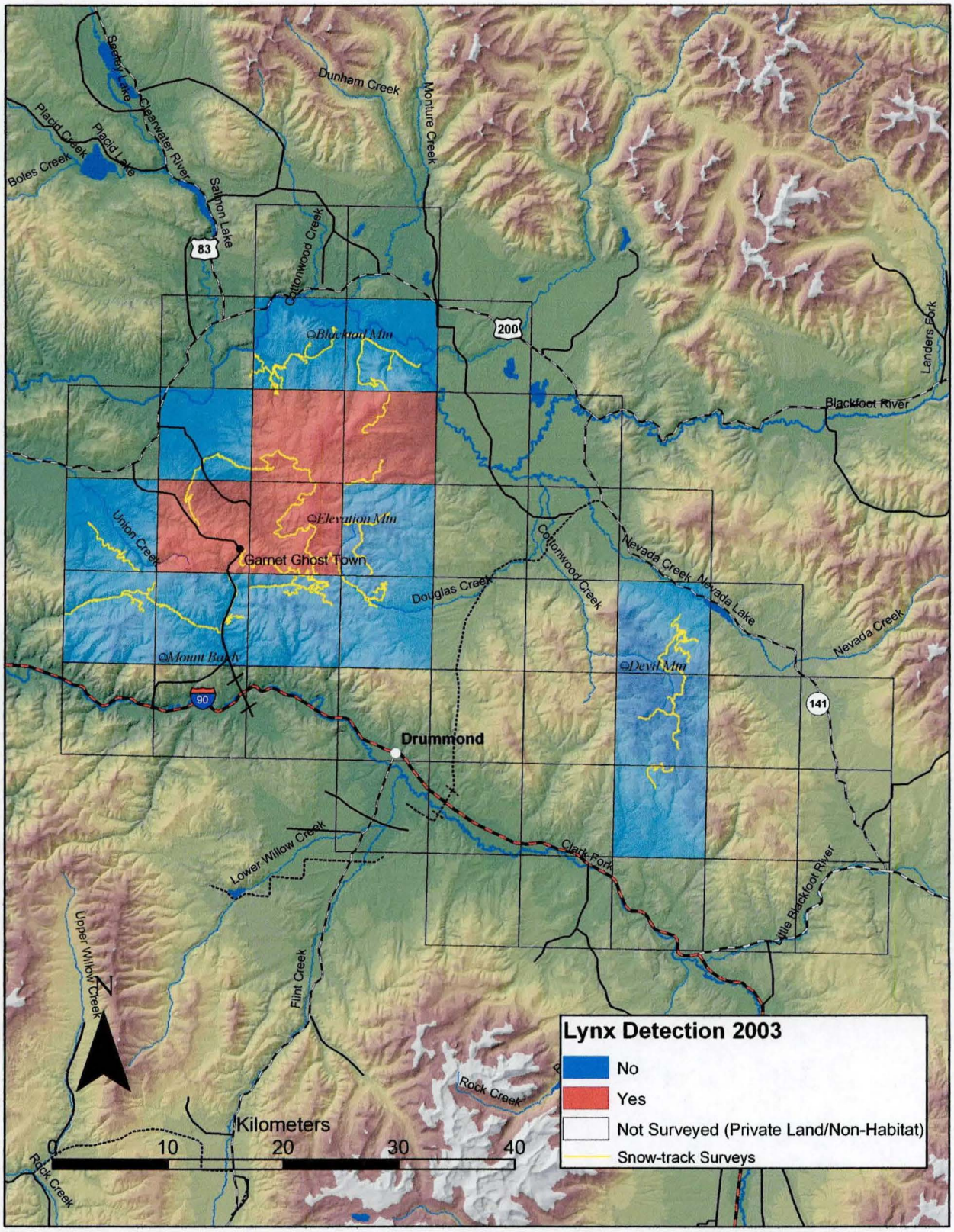

Figure 5. Survey pixels and snow-track survey routes in the Garnet Range, Montana, 1 January –20 March 2003.

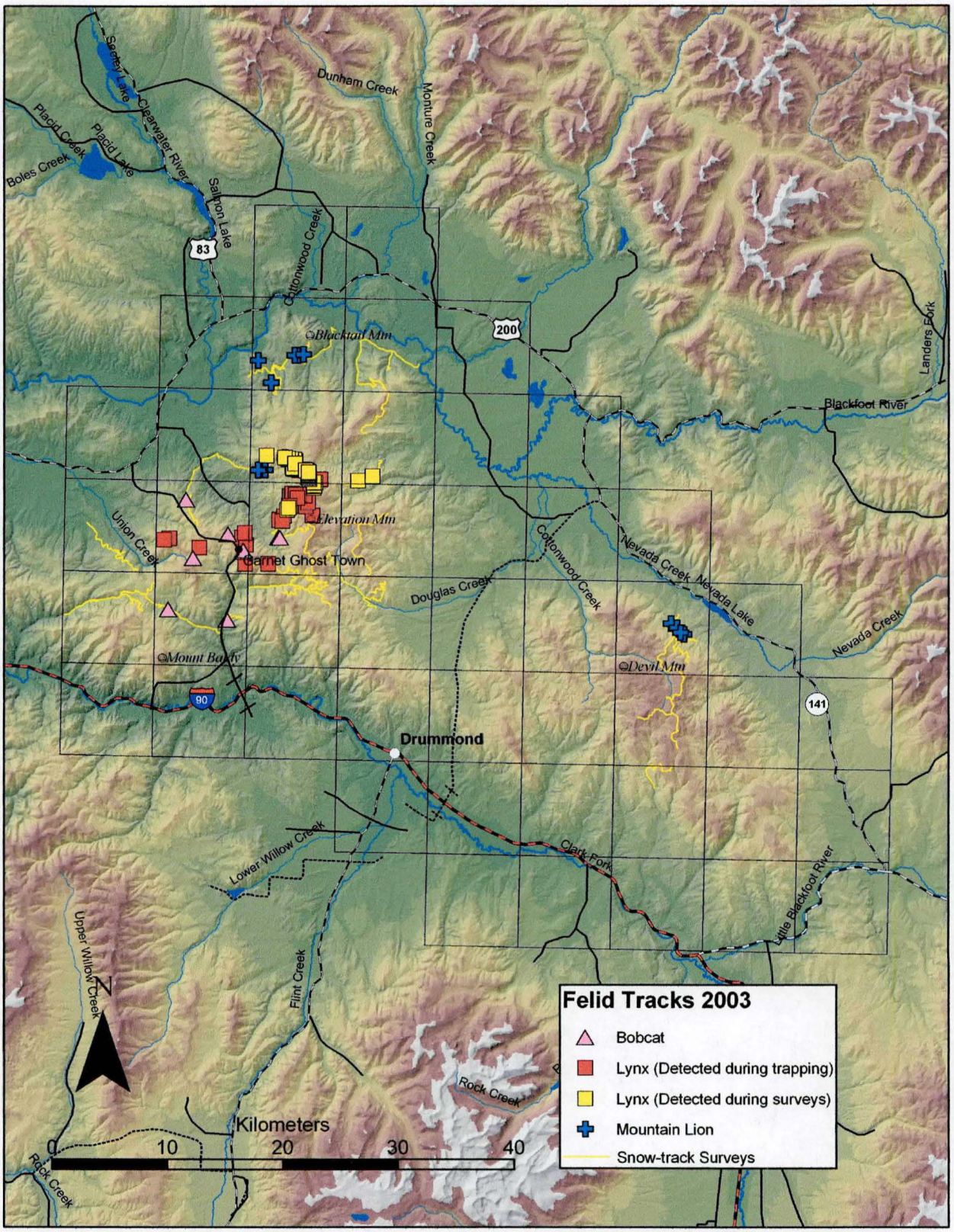

Figure 6. Felid tracks detected during snow-track surveys in the Garnet Range, Montana, 1 January –20 March 2003.

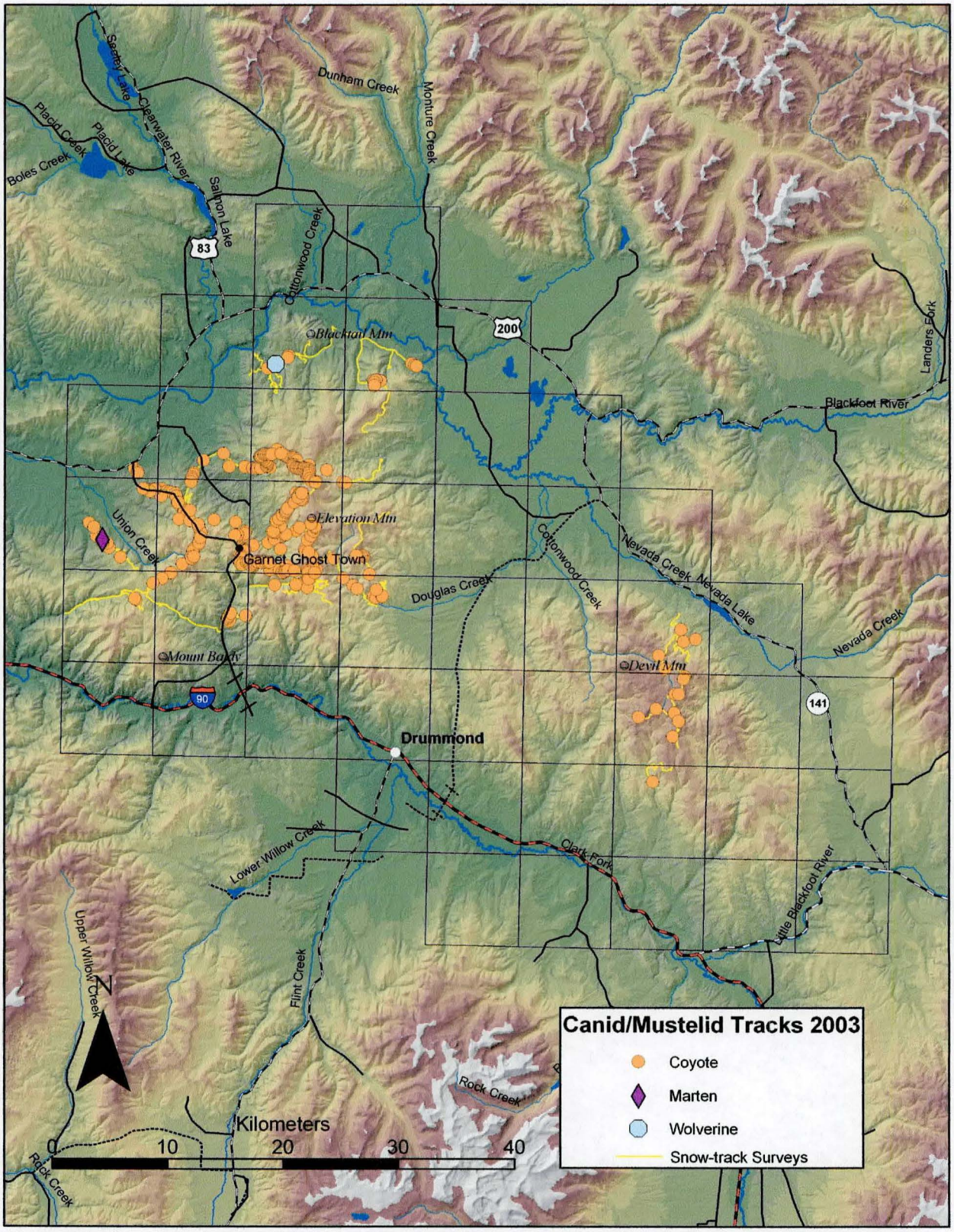

Figure 7. Canid and mustelid tracks detected during snow-track surveys in the Garnet Range, Montana, 1 January –20 March 2003.

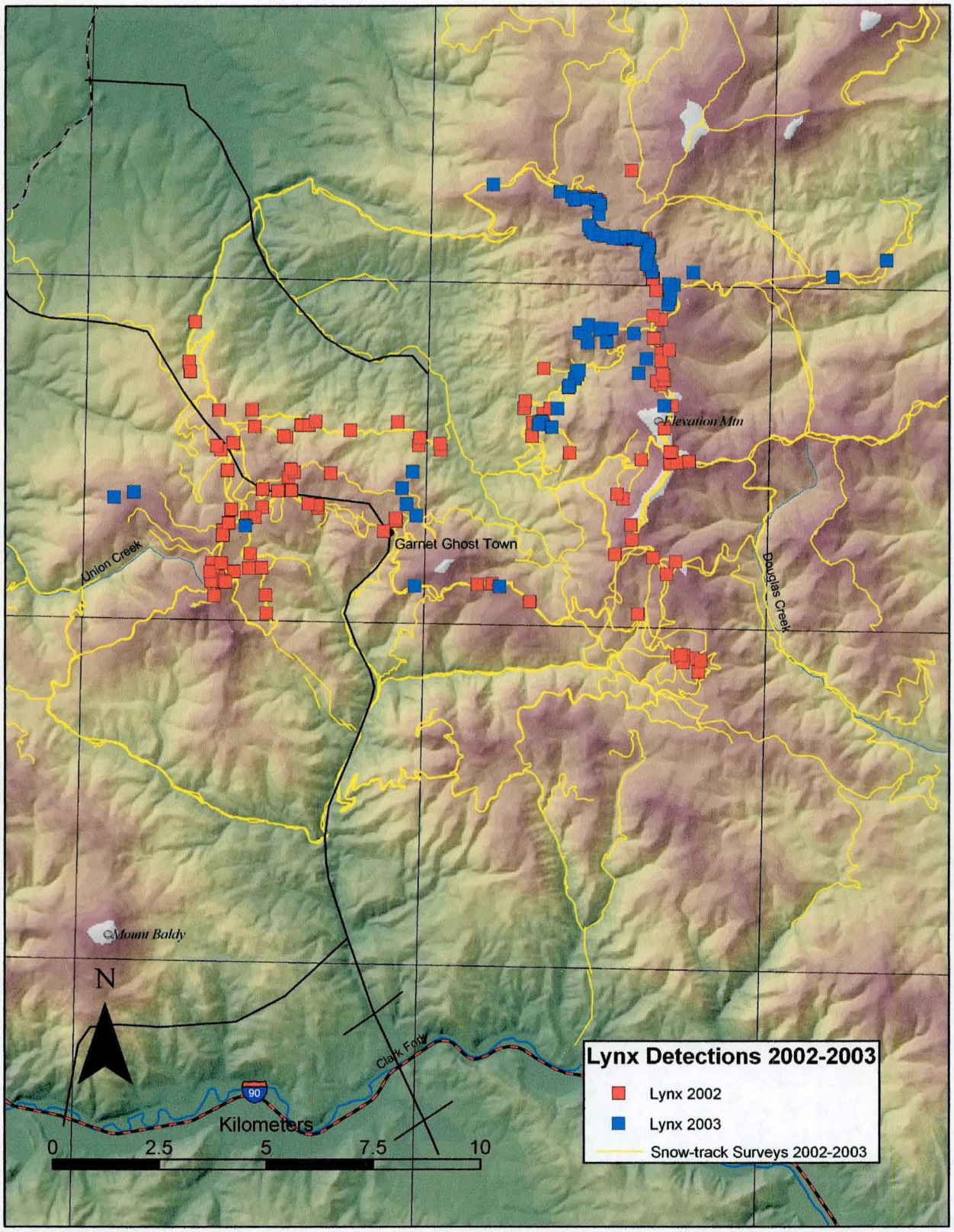

Figure 8. All lynx tracks documented during snow-track surveys in the Garnet Range, Montana, winters 2002 and 2003.

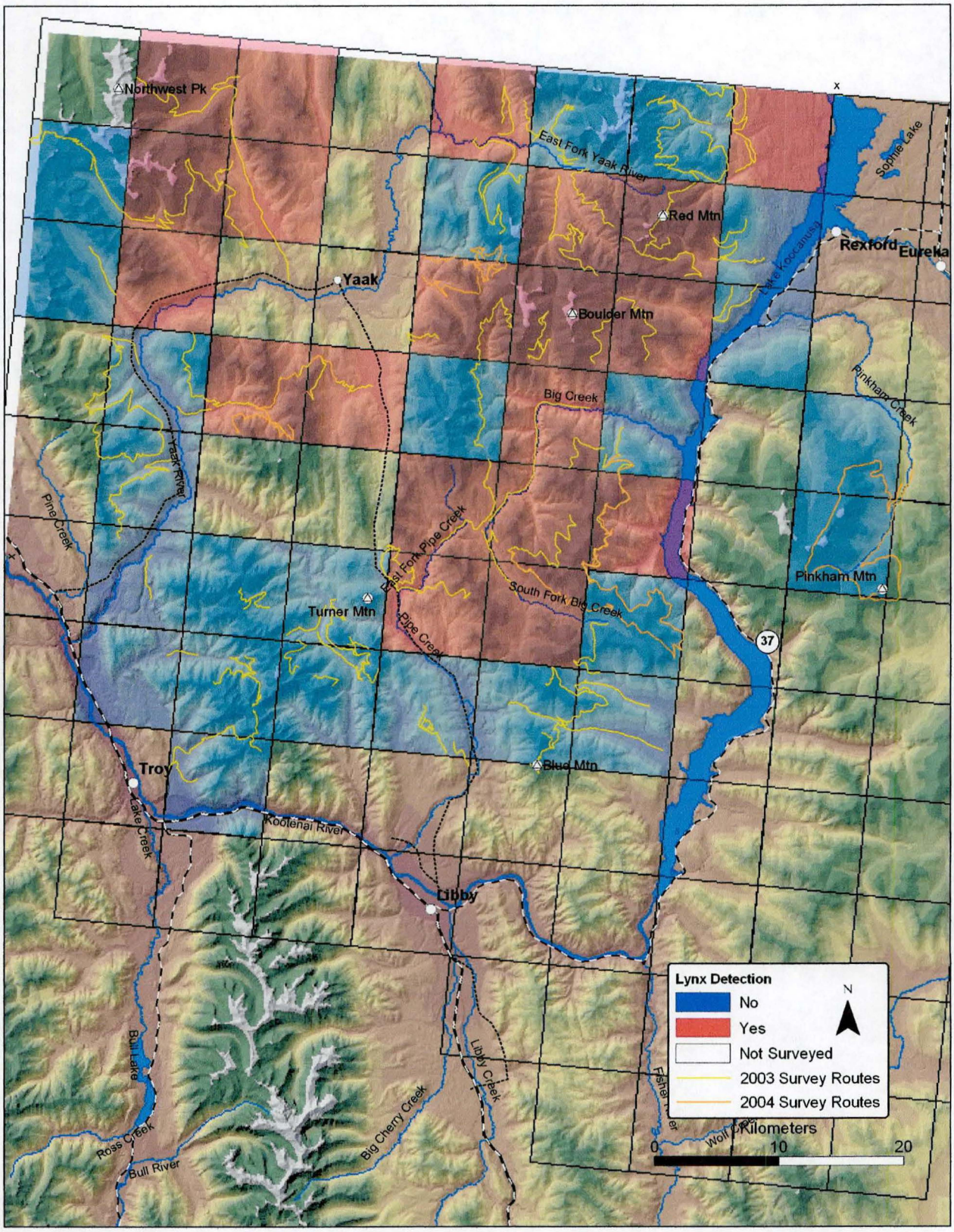

Figure 9. Survey pixels and snow-track survey routes in the Purcell Mountains, Montana, 26 January – 4 April 2003 and 21 January – 4 March 2004.

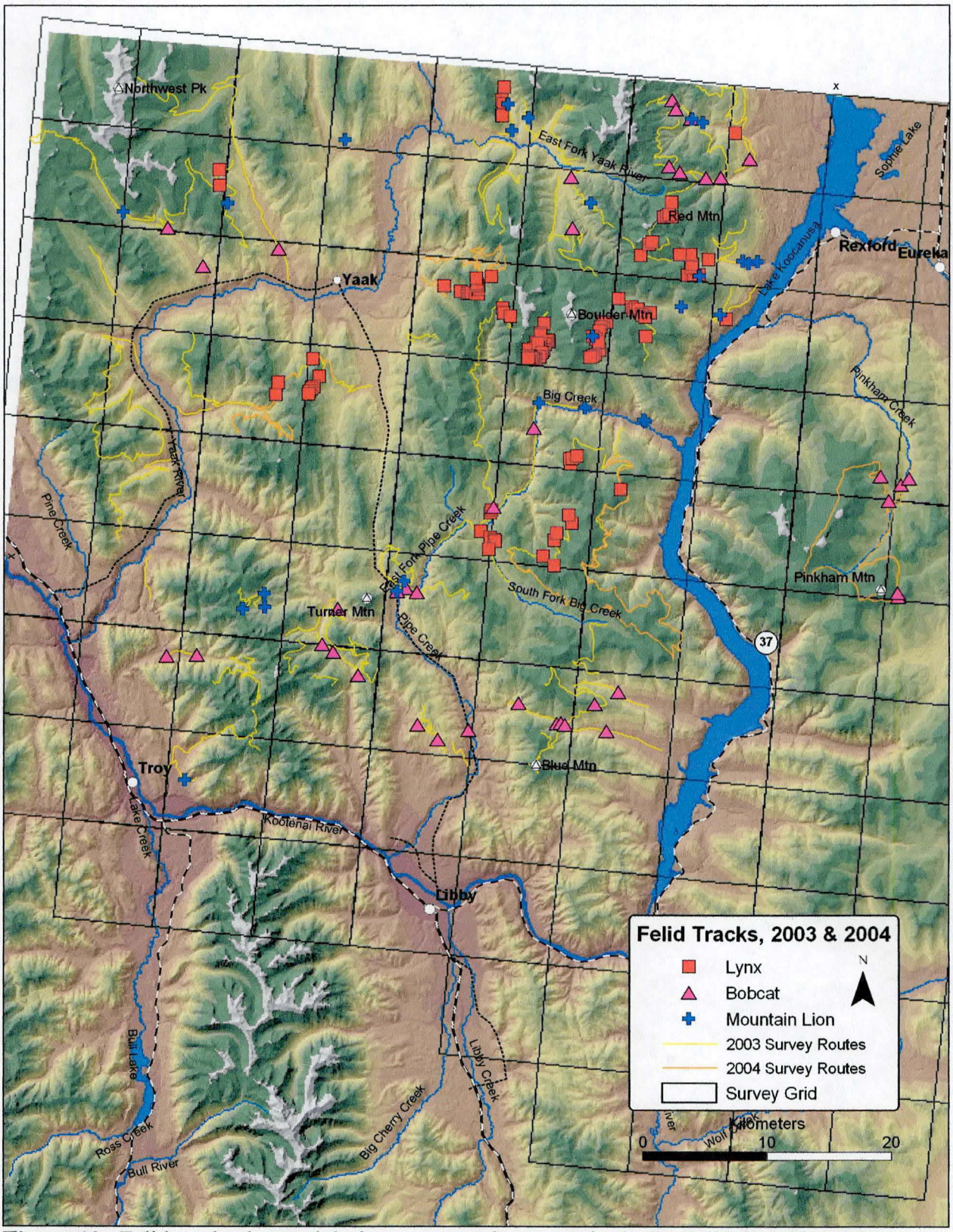

Figure 10. Felid tracks detected during snow-track surveys in the Purcell Mountains, Montana, 26 January – 4 April 2003 and 21 January – 4 March 2004.

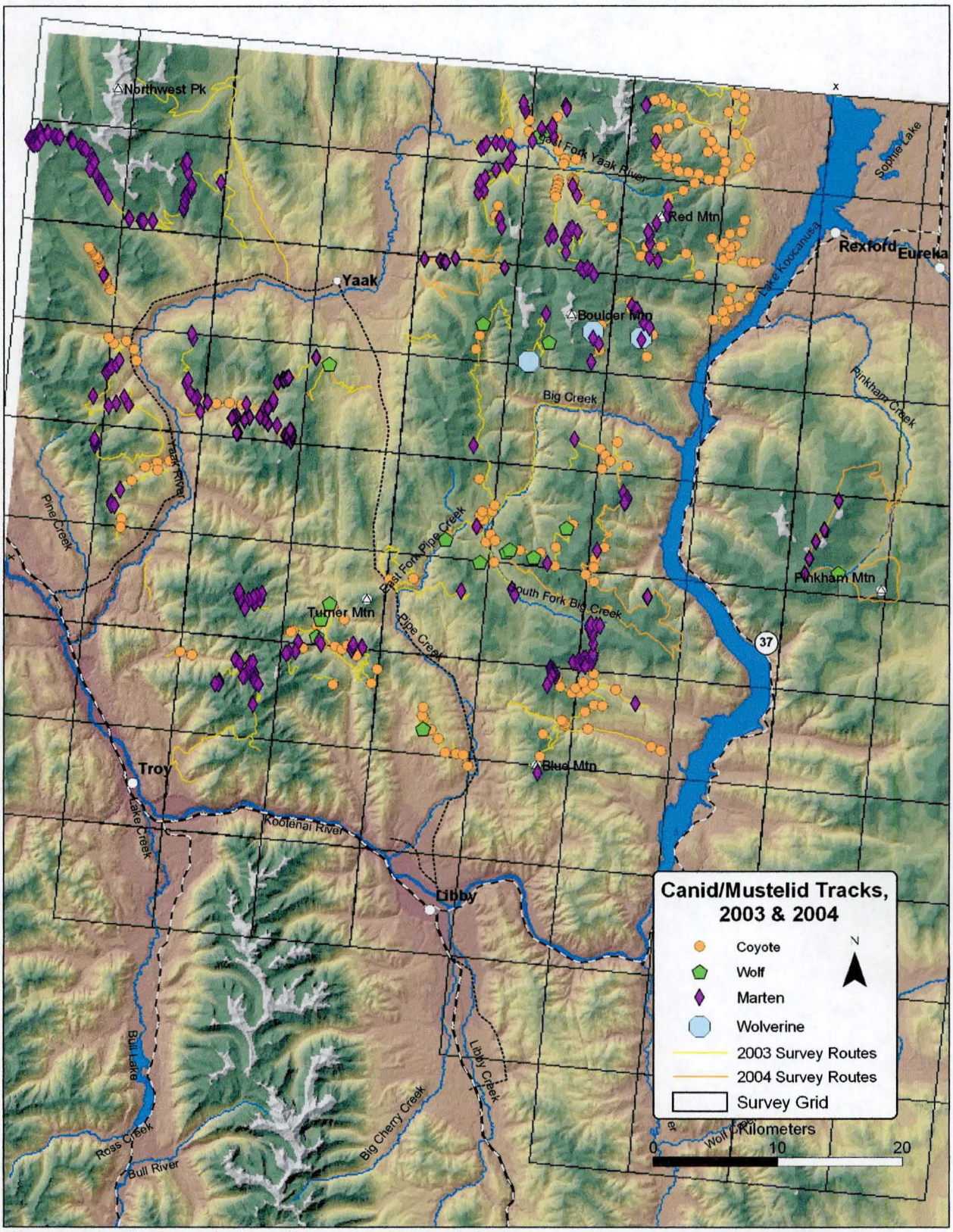

Figure 11. Canid and Mustelid tracks detected during snow-track surveys in the Purcell Mountains, Montana, 26 January – 4 April 2003. *Note*: We stopped recording individual coyote tracks on 7 February 2003.

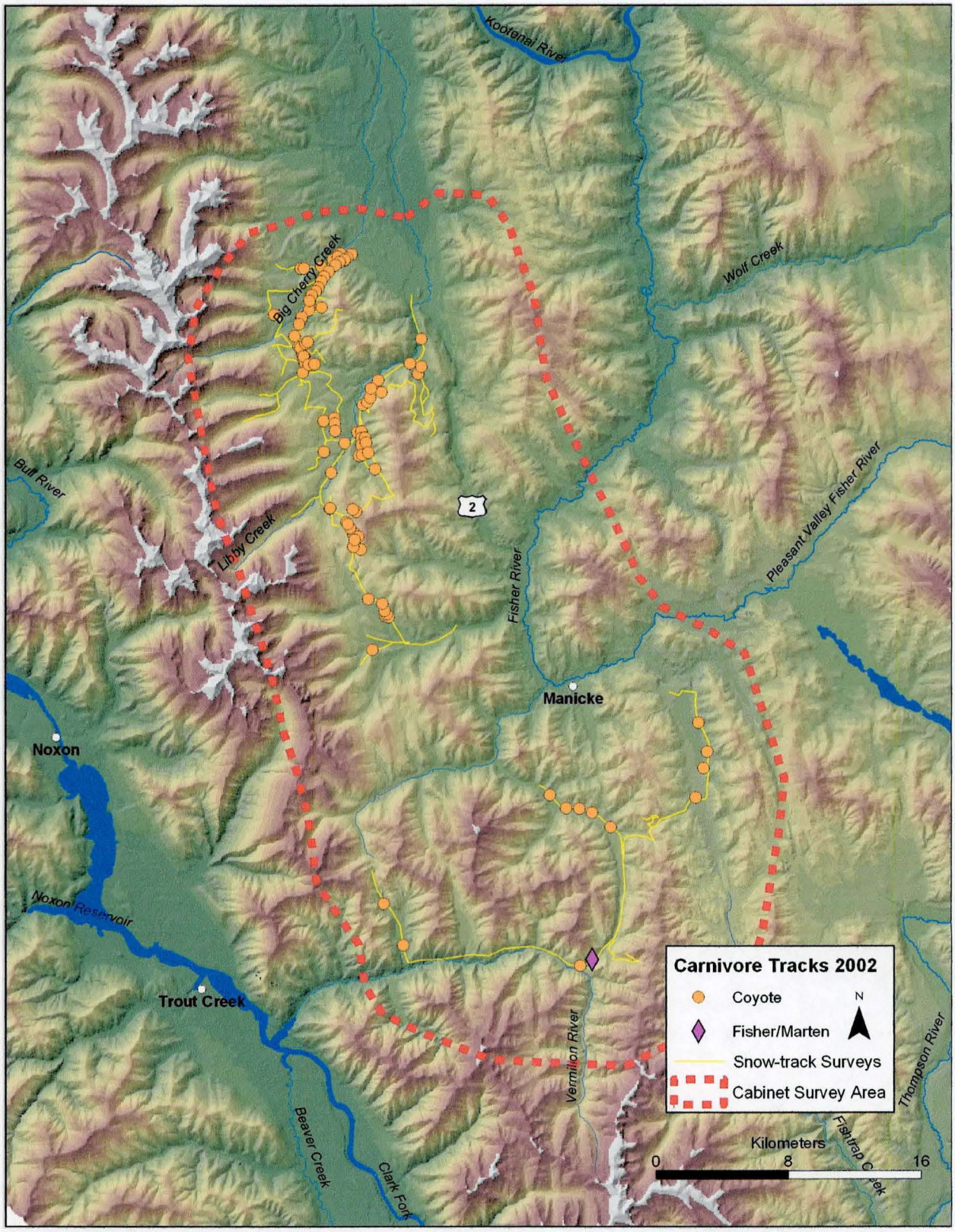

Figure 12. Carnivore tracks detected during snow-track surveys in the Cabinet Mountains, Montana, 13 March – 19 March 2002.

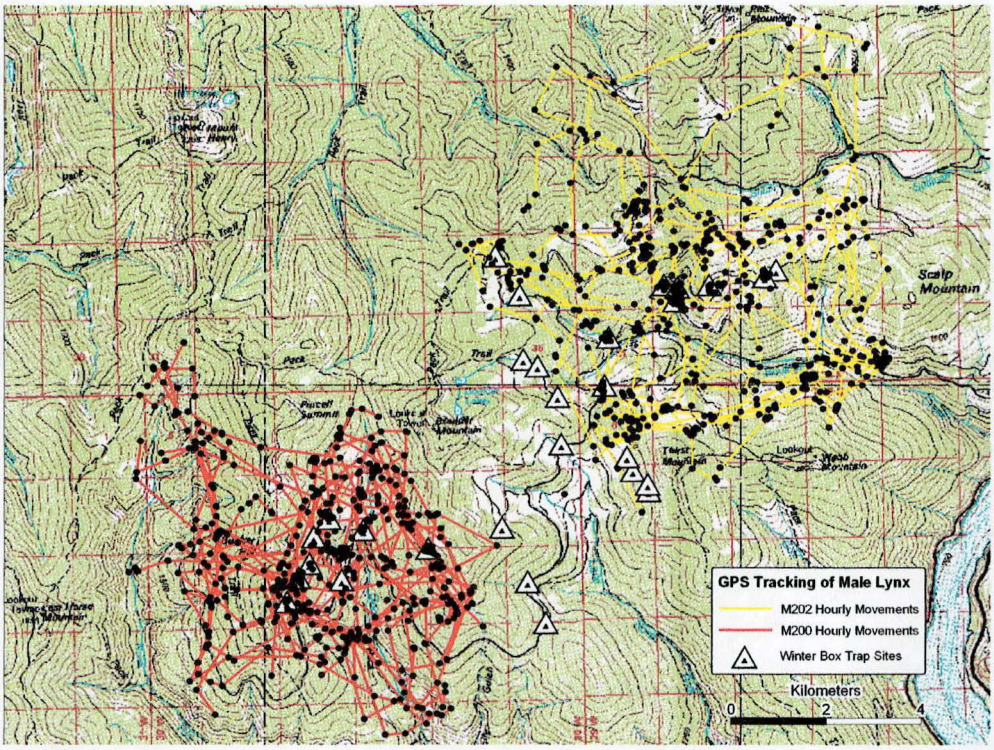

Figure 13. Pilot GPS locations collected every hour for 2 male lynx (M200 & M202) in the Purcell Mountains, Montana, 4 February – 23 March 2004.

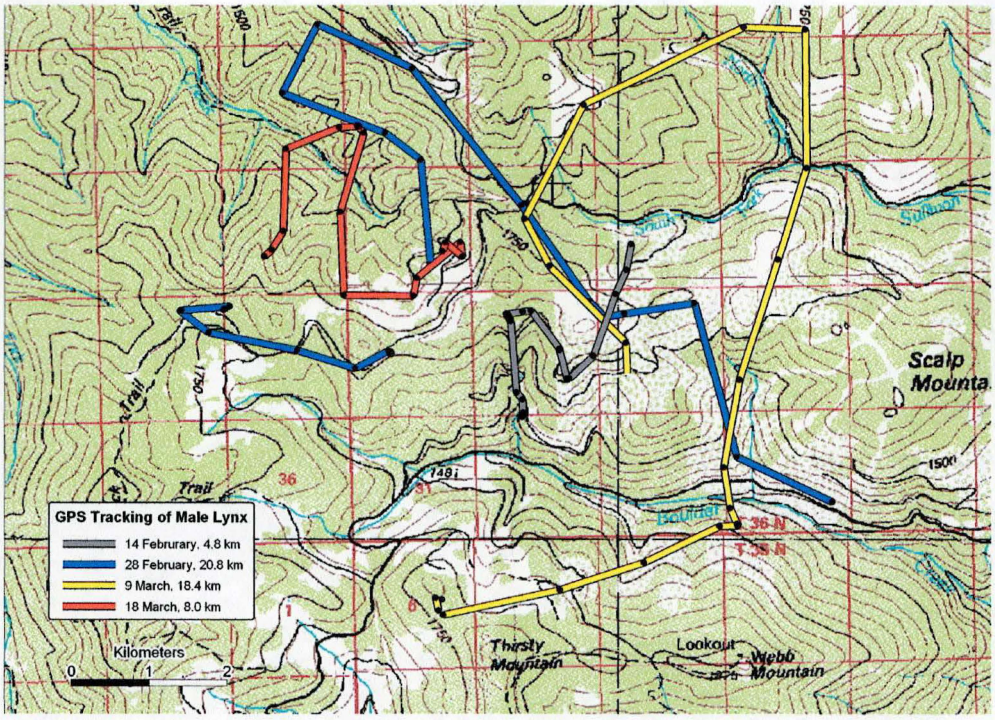

Figure 14. Four samples of 24-hour lynx movement paths as represented by hourly GPS locations for a male lynx (M200) in the Purcell Mountains, Montana, February and March, 2004.

Figure 15. Two views of a lynx den site (F104) and 6 kittens in the Garnet Range, Montana, 25 May 2004.

Figure 16. Two views of a lynx den site (F212) and 4 kittens in the Purcell Mountains, Montana, 25 May 2004.